DOCUMENT RESUME

ED 156 172 IR 006 158

AUTHOR Olivier, William P.; Scott, G.F.
TITLE Large Scale Development of Computer-Based Instructional Systems.
PUB DATE 78
NOTE 12p.

EDRS PRICE MF-$0.83 HC-$1.67 Plus Postage.
DESCRIPTORS Adoption (Ideas); College Teachers; *Community Colleges; *Computer Assisted Instruction; *Cooperative Planning; Diffusion; Educational Development; *Educational Innovation; *Interagency Cooperation; *Program Development; Teamwork
IDENTIFIERS Ontario (Canada)

ABSTRACT

The Individualization Project at the Ontario Institute for Studies in Education (OISE) was organized on a cooperative basis with a federal agency and several community colleges to move smoothly from R&D to a production mode of operation, and finally to emphasize dissemination of computer courseware and systems. The key to the successful developments in computer assisted instruction (CAI) over an eight-year period was the cooperative nature and mutual respect demonstrated by all Project participants. This developmental cooperative approach has implications for the successful introduction of other instructional technologies into educational systems as well as CAI. Description of the project, including interagency cooperation, project organization, courseware and technical development, and growth patterns, provides suggestions for successful implementation of educational innovations. (CMV)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED156172

U S DEPARTMENT OF HEALTH,
EDUCATION & WELFARE
NATIONAL INSTITUTE OF
EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

LARGE SCALE DEVELOPMENT OF COMPUTER-BASED INSTRUCTIONAL SYSTEMS

by

W.P. Olivier

and

G.F. Scott

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

William P. Olivier

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

TK0006158

Large Scale Development of Computer-based Instructional Systems

by

W. P. Olivier & G. F. Scott

Many projects have begun and ended and millions of dollars have been spent on research, development and demonstration of Computer-Aided Instruction (CAI). Much of this effort has been wasted, except for learning what not to do. In the U.S.A. large projects have been funded federally. In Canada, with no extensive federal funding, a more conservative approach to development was necessary.

The major cause of project failure likely has been the lack of a total process approach to the research, development and dissemination phases. To achieve success in CAI development all aspects from initial conceptualization to installation must be considered as an interacting system. Projects have been funded for a single goal such as to develop: a CAI language, a CAI delivery system, courseware (instructional programs), etc. Even today most CAI projects only provide an author language and hope the creative teacher will produce high quality CAI. No matter how much technological support is provided a potential author, the task of producing good CAI and getting it accepted is monumental. CAI production could be compared to giving an amateur photographer a TV studio and asking him alone to produce a weekly series. Obviously the amateur would need help from professionals, not only in directing, producing, camera work, lighting, etc., but also in the very crucial areas of advertising and distribution. Still many CAI professionals expect teachers to be multi-disciplinary specialists without special training and support.

Interagency Cooperation

The Individualization Project at the Ontario Institute for Studies in Education (OISE) was organized on a cooperative basis with a federal agency and several community colleges. There were several reasons for a cooperative approach. Financial considerations and their typical restraints certainly contributed to the joining of forces. The National Research Council of Canada (NRC) had a large computer, the OISE and colleges did not. The federal government in Canada has no educational mandate; education is a provincial matter. The NRC Information Science Section, a federal government research laboratory interested in CAI research across Canada, could neither fund projects nor develop courseware themselves. The NRC could supply computer time and develop software and hardware. OISE had the skills to author courseware but suspected anything they produced in isolation would go unused. The colleges were new and full of both problems and eager faculty. Detailed accounts of these

LR006 138

early developments and references to other related developments can be found in Olivier (1973) and Olivier, et. al. (1975).

The main design goals were to produce needed courseware and computer software system, move smoothly from R&D to a production mode of operation and to emphasize dissemination of courseware and systems. The project has grown to a coast-to-coast multi-processor network with distributed network control computers serving over 10,000 students in semester-length courses each year.

Project Organization

Teacher role. The project began with college teachers, given the support of their administrations, working about fifty percent of their time in defining goals and instructional materials. Any time less than fifty percent was not useful. Teacher responsibilities were setting goals, objectives, tests, instructional materials and strategies for courses. A needs analysis had been conducted earlier and pointed to a first year remedial mathematics course for business and technology students in community colleges.

Planning for dissemination. The teachers comprised a committee which had representation from around the province of Ontario. In producing an instructional innovation, the project organizers felt that a geographically representative set of trained authors would assist the dissemination effort. If a selling of CAI was to occur it was best done on a low key approach and from experienced teacher/users. Teachers could be skeptical about promotional activities by outsiders, but when another teacher had participated in the development a more convincing presentation could be made to other teachers inexperienced with CAI. The project was developing local change agents. At regional curriculum meetings a teacher working on the CAI project usually gave a presentation, not of a research project, but of the actual materials production which was occuring to solve their needs. Interest generated through peer contact was more likely to result in diffusion of CAI usage than if an expert offered workshops and demonstrations when no foundation had been provided by other teachers.

Controlled expansion. The slow and steady growth by a group of people who believed in what was being accomplished gave the project a firm foundation. Perhaps the project was fortunate in not having large funding and had to compile skills and facilities among many agencies. The growth was controlled and subsequent steps built upon outcomes of earlier stages. Committees were expanded to a limit of seven to remain managable and each new course development committee incorporated a few experienced teacher/authors. Teachers also saw the benefits of working in committees when a one unit input (one teacher's efforts) in a committee of

seven produced five units of output. This is not to say there were no frictions and arguments among the teachers, but differences were usually resolved quickly and criticisms were constructive.

OISE staff role. The OISE staff performed several functions to support the teacher committees. Teachers were trained in 2-3 day workshops covering CAI techniques. Workshops are still held annually. Although the authoring language CAN (Olivier, 1977) was taught to the teachers, little direct use was made of this knowledge except to keep in mind some of the display, response and response judging restrictions of the system. Once the course structure and instructional strategies were decided upon, a format was created for specifying the tests and instructional materials, and these pages were used by OISE coders to produce the courseware. The teachers, working with OISE staff, were thus free to design the student/computer interaction without the drudgery of coding and debugging. OISE coders could follow good and efficient coding practices such as modularity, item generation, algorithmic response judging, and maintain documentation. Most teachers have been uninterested in coding, indeed they have pursued an instructional career not programming. No matter how sophisticated the author language, a CAI project will exclude a lot of valuable and creative instruction if teachers are forced to use an author language. On the other hand, most automated systems to date have produced sterile interactions. In addition, coders are paid about half the salary of teachers. The division of labor among specialists was extremely helpful and likely accelerated production.

An OISE research officer acted as a computer programming intermediary for the teachers. The research officer (RO) had to be familiar with what the teachers wanted to accomplish, as well as, what was good CAI. The RO had to be familiar with the constraints of the CAI system to be able to direct the teachers into objectives they could reasonably accomplish. Acting as convener, secretary and committee chairman were other functions performed by the RO. The task of supervising the coders in the Instructional Programming Group (IPG) also fell to an RO. These individuals were in effect the course authors with advice and materials provided on one hand by the teacher committee and on the other by the IPG. Advice and direction was also given by the OISE project directors, Olivier and Scott. As might be expected, the ROs were unusually capable, but not much harder to find than a good CAI author that has to use an author language and alone create a course. Formative evaluation design, data collection and analysis were other responsibilities of the ROs.

Cooperative directorate. Course development functioned smoothly, but the directors were aware that the OISE was in charge of a large number of teachers from different colleges

with no formal body to oversee the production. To solve this reporting and accountability function and also to ensure continued development and cooperaton at higher levels within the colleges, an advisory group was formed. Usually a dean or academic vice-president represented each college. This advisory group divided the responsibilities for course production among themselves. For example, when it was decided to produce courses in Mathematics of Finance and Technology Mathematics to follow the Prerequisite Mathematics course, different colleges committed teachers to each group. This advisory group is still functioning today. The OISE has withdrawn from full voting membership as part of the planned weaning of the project. During this next period the structure and skills which have been developed among the colleges hopefully will continue to work and more courses be produced cooperatively. Should the OISE presence be required, as exemplified by large scale local production of courseware without cooperation or coordination, the Institute will again act as convener and organizer until such time as organizational support can be withdrawn.

Courseware Development Assumptions

A number of assumptions were made about the development process. These assumptions came out of the collective experience of the authors of this paper. Olivier had been a doctoral student and research project director of the CAI laboratory at the University of Texas and taught mathematics at the high school level. Scott had been a high school mathematics department head and been involved in educational data processing system design for software packages such as school scheduling and financial systems. Both Scott and Olivier agreed on a number of assumption which had been seen as causes of failure of earlier efforts in development and dissemination.

Perception of problem. Before CAI development could even begin, teachers had to perceive that a problem area existed and that existing diagnosis and instructional techniques were not solving the problem. Too often, projects have produced a solution and delivered a package to teachers without teachers being aware of the problem. More often than not the teachers response will be either: what problem, or they will reject the solution as not fitting their needs.

Adaptability to student needs. The product must also meet a broad range of needs, because of the development costs involved. When there is agreement of goals and objectives in advance of production of a course, widespread acceptance and use is more likely. Compromises are inevitable, but courses produced to meet local needs are not accepted by other schools as easily as courses cooperatively developed. Since courseware must meet a broad range of needs, there must be some means of adapting the course to local needs. This adaptation mechanism must not be through

program modification and the subsequent instability and unreliability of courseware, but by the ability to select portions of a course. The implementation of this feature can be through teacher control functions for selecting topics and perhaps their order within a CAI course, and/or if the teacher allows, by complete learner control functions within the course.

Careful introduction. Any new technological innovations such as CAI, coming into a conservative establishment like schools must, at least initially, fit into the existing educational system and evolve. Any radical innovation, natural for CAI such as self-pacing and continuous intake, does not merge with existing semestered systems. Even administrative details such as funding or legal statutes can be based on teacher-student contact hours. When a medium such as CAI can dramatically increase the efficiency and consequently reduce the student contact time, problems can accrue to the system. Impact analyses must be conducted so that the introduction of CAI, on more than just a casual basis, progresses smoothly.

Cost of delivery. School administrators are watching expenditures as never before, and any unnecessary expense is not tolerated. Extra and unnecessary frills in CAI should not be allowed and courseware must have proven effectiveness and low cost. Student motivational reasons have been an umbrella covering a lot of unnecessary digital cartoon graphics, pointing response detection, colour and audio which dramatically increase the cost of delivering CAI.

Evaluation. Effectiveness of courseware should be demonstrated. The most generalizable summative evaluation is one which has results from many experiments and not one large study. CAI is used differently, that is with different degrees of integration into existing programs, and results from several implementations are a better indicator of likely success for a school than a single experiment where the use of the courseware might differ. Courses should undergo careful formative evaluations and the final product should be of as high quality as possible.

Teacher acceptance. Threats to teachers' jobs, especially with declining school enrolments and in financially restrictive times, could cause outright rejection of CAI. A slow and steady growth using teacher peers to disseminate ongoing results helps to avoid the fear of job loss. Teachers can report the assistance which CAI has been and that no teachers have lost jobs because of CAI. On the other hand, administrators can report how they have slowed the growth of the labour intensive teaching function by employing technology rather than hiring new staff to achieve lesser results. Teachers who have participated in the development of courseware can better relate to new teacher users.

Courses designed for students. Courses should be easy to use and there should be consistency of operation from one course to another. Many users of systems other than CAN have experienced the frustration of learning to use a new technology, procedures and conventions when moving from course to course. Teachers using several courses with their students have experienced the differences and inconsistencies of reports from the system, if reports even exist. Learner control is, in essence, a structural way for students to ask questions and direct the operations of courseware. If the student has to learn a new vocabulary for each course then much valuable time is being wasted. This problem is compounded when a CAI course is a few minutes to a few hours in length rather than something comparable to a semester's work.

Courses adapt to individuals. Courses should adapt, not only to local teaching goals, but also to individual student differences. Adaptive techniques such as hierarchical branching structures, variable-length testing, learner control, program modularity and generative coding with algorithmic response analysis such as discussed by Olivier and Lomberg (1974) make adaptive CAI easy to implement.

Other assumptions were also made by the project designers with respect to the more technical aspects: computers, terminals, programming and data communications.

Technical Assumptions

A detailed account of the technical developments and references to other documents of this project can be found in Olivier (1976), Olivier and McClare (1977), Luts (1977a,1977b), and Dinniwell et. al. (1975). When the project began, the only dedicated CAI system commercially available was the IBM 1500 Instructional System. Since data communications and low cost were basic requirements, this system was not acceptable. It was also decided to support earlier work in the CAN language and to allow for complex mathematical functions, so other systems such as COURSEWRITER-3 were not acceptable. With a view toward the lowest possible operational and developmental costs and transportability, it was decided to code the developmental operating system in FORTRAN, a tactic also used for PLANIT. Suffice it to say that this system met all criteria except low operational cost. The OISE DECsystem-10 would run thirty CAN terminals under the FORTRAN coded CAN operating system and 300 terminals under the current machine language implementation of the CAN/CAI-CANNET operating system. A faster processor in the DECsystem-10 series will presently support nearly 600 simultaneous CAN terminals.

User supported hardware. When the R&D phase of the first course, Prerequisite Mathematics, was nearing completion and the NRC DECsystem-10 computer would no longer

be available, the colleges were asked to consider support of the courseware. The OISE offered to consult on the feasibility of a CAN/CAI system for any mainframe which was selected. Seneca College in Toronto was the first to decide to upgrade their equipment for CAI and they purchased a Burroughs B6700. The OISE systems staff produced a CAN/CAI-CANNET operating system for this equipment, and the system is being leased from the OISE to installations around North America. Today the Seneca system serves over 200 simultaneous CAN terminals with less than twenty per cent of the system resources. The system met the cost goals; Seneca charges less than one dollar (Canadian) per hour for CAN/CAI usage.

Algonquin College in Ottawa decided to upgrade their computing equipment to provide CAI the next year, and OISE made the same offer. Algonquin purchased a DECsystem-10, and the OISE developed a CAN system based on the machine language. Algonquin still uses a version of this system. The following year the OISE purchased a DECsystem-10, and due to some unreliability and problems with the earlier system, recoded the DECsystem-10 CAN operating system. This latest OISE DECsystem-10 CAN/CAI-CANNET operating system is now being leased by several institutions in North America.

Use existing technology. It was important, at that time, to use existing equipment and technology. Too many projects have been unable to meet goals when new technologies have been critical to daily operations. Thus, the project began with existing computers capable of performing, albeit not ideally, the task of CAI. By the fall of 1979 it is reasonable to expect that a dedicated CAN/CAI system should be available further reducing the cost of delivering CAI.

Standard terminals. No specialized terminals were used initially for the courseware developments. Other CAI systems have encountered too many difficulties and delays when there has been a reliance on specially designed terminals. Cost, reliability and delivery requirements kept us from depending upon special terminal designs. OISE staff acquired many one-of-a-kind terminals and even produced prototype terminal equipment but never recommended any to participating colleges. Most colleges purchased Teletypes, Texas Instrument thermal printers, DECwriters, Hewlett-Packard 2640 CRTs and more recently Volker Craig CRTs. Experience showed the first four types to be highly reliable. Courseware such as Accounting and Metric Games use the graphics facilities of the Hewlett-Packard CRT.

Data communications. Data communications was a continuous problem. With a geographical spread of project participants, necessary for broad utility of courseware and ease of diffusion, data communications was necessary. Not only were communications necessary from terminal to host but

also among CAN host computers. For ease of course maintenance only one copy of a course under development exists. At first the NRC system was used for field testing, and later the OISE took over this role. Once a course is evaluated it is installed on all appropriate production systems. Communications processors initially served a concentration and data verification function. The CANNET processors were developed to provide additionally a self maintaining, host-independent message switching system. Thus, a student on any CANNET processor is automatically routed through as many as four CANNET processors to the appropriate CAN host system.

The CANNET communications system is similar to the older ARPAnet or packet switching. CANNET processors dramatically reduce communication costs where several terminals are located together. The CANNET processors also are equipped with loading, diagnostic and recovery routines for neighbour CANNET processors. The system is now automatic and does not require human intervention except for hardware maintenance and repair.

User convenience, reliability and low cost were overiding concerns in the development of the CAN/CAI-CANNET system. It is felt that these goals have been met as indicated by the growth in usage.

Growth Patterns

Growth of usage in Ontario has been steady. Were it not for saturation of computer resources at the Ontario service centres: Seneca and Algonquin colleges, many more student terminals would be in use. This school year a predicted plateau was reached. Seneca College can serve, because of other demands upon their machine, no more than 280 simultaneous CAN users. The OISE system, also because of other applications, fills at 40 simultaneous users running developmental courses. It is anticipated that 10,000 students will complete full semester equivalent CAI courses this year, the same as last year. This represents usage at most of the Ontario colleges and other colleges across Canada. The figure for usage on CAN systems in the U.S.A. is unknown at this time.

Comprehensive courseware. The number of full semester-length college level courses has grown from the Prerequisite Mathematics course to include Technology Mathematics, Mathematics of Finance, Chemistry, Accounting and Electricity. Other courses comprising less that a semester's work also exist. The largest production effort now is a complete mathematics program for intermediate (7 - 10) grades. Increasingly, it is the availability of high quality courseware that convinces institutions to adopt CAI, not just a sophisticated hardware system.

Machine translation. We have completed but not fully tested a COURSEWRITER-2 and COURSEWRITER-3 to CAN translator program. This program could allow an educational user access to all the COURSEWRITER and CAN courseware. The OISE would like to use the stat1 course developed for the IBM 1500 system at the University of Alberta. Other educational users could make use of this translator program and other translation features will soon be possible. A doctoral student at the OISE is producing a table driven translator to accept the definition of course authoring languages and convert these to the CAN intermediate language (Voyce and Olivier, 1978).

Testing system. A computer-based test construction and delivery system has been produced by the OISE under contract to Seneca College and is available to Burroughs CAN/CAI system users. This operating system is written in ALGOL and no attempt has been made to rewrite in machine language as an extension to the DECsystem-10 CAN/CAI system. The testing system is a generalizable system of item classification and retrieval which accommodates different curriculum philosophies. System produced tests are either given to groups in printed form or interactively by a computer terminal to individuals. Teachers can input items and retrieve complete tests for classroom use. The classroom tests are scored by optical scanning equipment and a report produced in moments. Students can use the self-testing facility to retrieve, as allowed, teacher created tests or, by specifying the types of items desired, create interactive tests. Items are coded by multiple selections from keyword categories. Each category selected is of equal weight and independent of all other categories. Weighting and dependence among categories is introduced when retrieving items. Users specify categories of interest, primary interest, excluded categories and the minimum number of category matches which must occur for item retrieval. The first item bank, implemented in 1976, contained items on health sciences. Other item banks are now operational.

The Individualization Project has become involved in practically every area of CAI activity in the last eight years. The key to these successful developments has been the cooperative nature and mutual respect all project participants had. This development approach seems to have implications not only for the introduction of CAI systems but also the introduction of other instructional technologies into educational systems. Early representative involvement of teachers supported and advised by "experts" was deemed critical for continued and widespread use.

REFERENCES

Dinniwell, J. D., Luts, J., Mikichak, P., Naess, L., & Olivier, W. P. Developing a delivery system for computer-assisted instruction. Canadian Datasystems. June 1975, 54-57.

Luts, J. CAN-7 Implementation and Systems Operation Documentation Burroughs B6700 Implementation. Toronto: The Ontario Institute for Studies in Education, 1977a.

Luts, J. CANNET Site Operation Handbook. Toronto: The Ontario Institite for Studies in Education, 1977b.

Olivier, W. P. Computer-assisted mathematics instruction for community college students. International Journal of Man-Machine Studies. 1973, 5(3), 385-395.

Olivier, W. P. & Lomberg, Evannah S. Student skill deficiencies and computer assistence. In Konrad, A. G. (ed.) Clientele & Community. Willowdale, Ontario: Association of Canadian Community Colleges, 1974, 58-67.

Olivier, W. P., McLean, R. S., Brahan, J. W. & Payne, C. A. Canadian cooperative computer-aided learning project. In Lecarme, O. & Lewis, R. (eds.) Computers in Education. Amsterdam: IFIP, North-Holland Publishing Company, 1975, 489-496.

Olivier, W. P. Cooperative development of a multi-processor CAL network. Proceedings of The 7th Ontario Universities Computing Conference. University of Waterloo, June 2-4, 1976.

Olivier, W. P. CAN-7 Author's Guide. Toronto: The Ontario Institute for Studies in Education, 1977.

Olivier, W. P. & McClare, R. CAN-7 Implementation and System Operation Documentation DECsystem-10 Implementation. Toronto: The Ontario Institute for Studies in Education, 1977.

Voyce, S. & Olivier, W. P. A solution to the problem of courseware sharing. Paper to be presented at the Canadian Computer Conference, Edmonton, 1978.